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Taxonomic Paper

New and known species of the genus *Campylaimus* Cobb, 1920 (Nematoda: Araeolaimida: Diplopeltidae) from North European marine habitats

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Abstract

Background

The genus *Campylaimus* is a broadly distributed but relatively uncommon genus of marine and brackish nematodes with 20 nominal species and one *nomen nudum.* Many species descriptions and redescriptions are based on very few (single) individuals, which limits our understanding of inter- and intra-specific variability and morphology-based species boundaries.

New information

Two new species were found in the Skagerrak off the west coast of Sweden. *Campylaimus triclados* sp. n. is characterised by body 0.59–0.69 mm long; cuticle without longitudinal striation; anteriormost edge of the amphid anterior to the oral opening; dorsal limb of the

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amphid equal to 1.6–2.5 labial region diameters in male, 1.9 labial region diameters in female; ventral limb of the amphid extends towards anterior part of the intestine in male and midpharynx in female, 4.3–5.5 times the length of the dorsal limb in male and 2.2–2.8 times the length of the dorsal limb in female; ventral limb of the amphid is as wide as the dorsal limb; interamphideal space extends further than the posterior end of the dorsal limb but not reaching the posterior end of the ventral limb; secretory-excretory pore opens posterior to the cardia; spicules 19–24 µm long; two precloacal supplements; tail equal to 4.3–5.6 anal body diameters in length, with conoid terminal part. *Campylaimus longispiculus* sp. n. is characterised by body 0.56–0.65 mm long; cuticle without longitudinal striation; anteriormost edge of the amphid anterior to the oral opening; dorsal limb of the amphid equal to 1.8–2.1 labial region diameters in male; ventral limb of the amphid extends towards anterior part of the intestine in male, 2.8–3.5 times the length of the dorsal limb in male; ventral limb of the amphid is as wide as the dorsal limb; interamphideal space absent; secretory-excretory pore opens posterior to the cardia; spicules 28–35 µm long; two precloacal supplements; tail equal to 4.9–5.3 anal body diameters in length, with clavate terminal part. In addition, following nine species are new records for the fauna of Sweden: *Campylaimus amphidialis, C. inaequalis*, *C. lefeverei*, *C. minutus*, *C. orientalis*, *C. rimatus*, *C. siwaschensis*, *C. striatus* and *C. tkatchevi*.

Keywords

Bratten, Diplopeltidae, Gullmarn fjord, identification key, new species, revision, Skagerrak, Sweden, taxonomy

Introduction

The genus *Campylaimus* Cobb, 1920 is one of the few nematode genera with its oral opening positioned subterminally, shifted to the dorsal side of the body. This unusual feature, subdorsal position of the mouth in nematodes, was even discussed by Fitch and Sudhaus (2002) in a context of evolution of body plans. However, precise morphology of the foregut in this genus was not always clearly understood by the researchers. The original description of the type species of the genus *Campylaimus, C. inaequalis* Cobb, 1920 stated that "*the mouth is ... on the ventral side of the head a little behind the anterior extremity*" (Cobb 1920). Even though this error was quickly corrected by Gerlach (1950), who clearly described the mouth to be placed on the dorsal side of the anterior end, Timm (1961) and Huang and Zhang (2006) followed the mistake made by Cobb (1920). Fortunately, all other publications, including most recent revisions by Villares et al. (2013) and Fadeeva et al. (2016), correctly describe the subdorsal to dorsal position of the mouth opening in all 20 known species of the genus *Campylaimus* (*Campylaimus abditus* Bussau, 1993 was described in an unpublished doctoral thesis (Bussau 1993) and must be considered a *nomen nudum*).

Twelve species of the genus *Campylaimus* were found during ongoing studies of marine nematodes along Swedish coasts and one species was collected in Germany. Two species are described as new to science and nine species are new to the fauna of Sweden. One species, *Campylaimus gerlachi* Timm, 1961 has already been recorded from the Baltic (Ólafsson and Elmgren 1997), but is re-described here in order to clarify its taxonomic status and its affinities to closely-related species.

Materials and methods

Bottom sediment samples were collected in multiple locations along the coast of Sweden: in the Baltic, Bothnia Sea and Bothnia Gulf, southern part of the Skagerrak and in Gullmarn Fjord. All samples were collected with a bottom dredge or box corer and further sieved in the laboratory before fixation. Nematodes were extracted from samples using a decanting and sieving method (smallest mesh sizes: 45 µm or 70 µm). Freshwater was used during sieving to induce an osmotic shock in nematodes, inducing their detachment from the substrate. Material retained on the sieves was immediately fixed in a 4% formaldehyde solution in the sea water.

For light microscopy, formaldehyde-preserved specimens were transferred to pure glycerine using the Seinhorst (1959) rapid method as modified by De Grisse (1969). Permanent nematode mounts on the glass slides were prepared using the paraffin wax ring method. All curved structures were measured along the curved median line. Measurements in all tables are presented in µm as mean ±SD and (range) where appropriate. Species descriptions and illustrations include only diagnostic, species-specific characters and are written in a "telegraphic style", while features characteristic to all species of the genus *Campylaimus* are given in the extended genus diagnosis only. Terminology follows Maggenti (2005). Abbreviations follow Decraemer and Hunt (2006). Specimens are deposited in the invertebrate collection of the Department of Zoology, Swedish Museum of Natural History, Stockholm, Sweden (SMNH).

Taxon treatments

Campylaimus Cobb, 1920

- Nemys http://nemys.ugent.be/aphia.php?p=taxdetails&id=2437

Type species

Campylaimus inaequalis Cobb, 1920

Description

Adult. Body cylindrical or fusiform, tapering anteriorly in the pharyngeal region and posteriorly in the tail region, straight or curved, either ventrally or dorsally, upon

fixation. Cuticle annulated along the entire body, annules equal in width; annulation starts at a level with the cephalic setae bases and extends towards the tail terminus; annules visually smooth or with fine longitudinal striation as seen under the light microscope. When present, longitudinal striation covers annules over the entire body length. Lateral alae present; anterior end of lateral alae may connect with the amphideal fovea in some species; posterior end extends towards tail terminus, ending at a certain distance from the tail tip. Body pores and epidermal glands absent. Somatic sensilla present. Labial region bluntly rounded, lips fused, tip of the anterior end often with much thicker cuticle. There are no cuticularised plates or other refractive structures around the anterior end. Inner labial sensilla invisible if present. Outer labial sensilla on the apical surface of the labial region. Of the outer labial sensilla, only lateral ones are often clearly visible under the light microscipe, located half way between the tip of the lip region and the anterior margin of the amphid. Cephalic sensilla setiform; their bases located at the base of the labial region, at various levels relative to the anterior edge of the amphid. Subcephalic and cervical sensilla, deirid and ocelli absent. Amphids usually similar in shape and size between sexes, sexual dimorphism, if present, is reflected in the relative length of the amphid or its sections: amphidial fovea an inverted U-shape with its ventral limb as long as or longer than the dorsal limb. Space between the amphidial limbs is variable in size (narrow or wide). Two species with the amphid in a shape of a longitudinal slit, assumed to be formed due to the reduction of the dorsal limb (Thanh and Gagarin 2011, Thanh et al. 2012). Amphidial glands often large, located at the level with the posterior part of the pharynx. Secretory-excretory system usually present; renette cell located opposite to the anterior part of intestine. Secretory-excretory ampulla present, located at the level of the intestine in the majority of species (if known). Cuticularised secretory-excretory duct very short, opens to the exterior via a pore, located at the level of the anterior part of intestine, except for *C. amphidialis*, in which it opens to the outside on the labial region. Nerve ring surrounding pharyngo-intestinal junction, just posterior to the muscular pharynx. Buccal cavity small and undifferentiated: cheilostom broad cylndrical, without rhabdia or sclerotisations; gymnostom and stegostom undifferentiated, closed or funnel-shaped, its slender lining continuous with that of the pharynx. Pharyngeal tubes absent. Pharynx uniformly muscular, cylindrical or fusiform, without visible subdivisions, with evenly distributed myofilaments; pharyngeal lumen uniform in thickness along the entire pharynx length; valves absent. Number and arrangement of pharyngeal glands and their orifices unclear. Cardia elongate, glandular. Tail conoid or subcylindrical, in some species with clavate terminal part. Three caudal glands present, their bodies and nuclei are incaudal; they open via a common spinneret.

Female reproductive system didelphic-amphidelphic with equally developed branches, ovaries outstretched. Spermatheca present in some species. Vulva equatorial, transverse (when described). Vagina straight; *pars proximalis vaginae* encircled by single sphincter muscle; *pars refringens vaginae* and epiptygmata absent. Tail most commonly with one pair of ventrosublateral setae located along the middle of the tail and one pair of sublateral setae located subterminally. Rectum short.

Male reproductive system diorchic, testes opposed: anterior testis outstretched and posterior testis reflexed. Spicules paired and symmetrical, arcuate, with weakly defined manubrium and subcylindrical shaft. Gubernaculum plate-like, without strongly developed apophysis. Some species with 2-5 precloacal supplements arranged midventrally; ventrosublateral precloacal and postcloacal sensilla absent. Tail most commonly with two pairs of ventrosublateral setae located along the posterior half of the tail and one pair of sublateral setae located subterminally.

Valid species

Campylaimus abnormis Nguyen Vu Thanh & Gagarin, 2011 (Thanh and Gagarin 2011)

Campylaimus amphidialis Fadeeva, Mordukhovich & Zograf, 2016 (Fadeeva et al. 2016)

Campylaimus arquatus Villares, Martelli, Lo Russo & Pastor, 2013 (Villares et al. 2013)

Campylaimus bonariensis Villares, Martelli, Lo Russo & Pastor, 2013 (Villares et al. 2013)

Campylaimus cylindricus Gerlach, 1956 (Gerlach 1956)

Campylaimus gerlachi Timm, 1961 (Gerlach 1950, Timm 1961)

Campylaimus gracilis Nguyen Vu Thanh, Nguyen Thanh Hien & Gagarin, 2012 (Thanh et al. 2012)

Campylaimus inaequalis Cobb, 1920 (Cobb 1920)

Campylaimus lefeverei Gerlach, 1956 (Gerlach 1956)

Campylaimus longispiculus sp. n.

Campylaimus minor Timm, 1961 (Timm 1961)

Campylaimus minutus Fadeeva, Mordukhovich & Zograf, 2016 (Fadeeva et al. 2016)

Campylaimus mirus Gerlach, 1950 (Gerlach 1956)

Campylaimus orientalis Fadeeva, Mordukhovich & Zograf, 2016 (Fadeeva et al. 2016)

Campylaimus patagonicus Villares, Martelli, Lo Russo & Pastor, 2013 (Villares et al. 2013)

Campylaimus ponticus Sergeeva, 1981 (Sergeeva 1981)

Campylaimus pulcher Fadeeva, Mordukhovich & Zograf, 2016 (Fadeeva et al. 2016)

Campylaimus rimatus Vitiello, 1974 (Vitiello 1974)

Campylaimus siwaschensis Sergeeva, 1981 (Sergeeva 1981)

Campylaimus striatus Boucher & Helléouët, 1977 (Boucher and Helléouët 1977)

Campylaimus tkatchevi Tchesunov, 1978 (Tchesunov 1978)

Campylaimus triclados sp. n.

Nomen nudum

Campylaimus abditus Bussau, 1993 (Bussau 1993)

Campylaimus gerlachi Timm, 1961

- Nemys http://nemys.ugent.be/aphia.php?p=taxdetails&id=121400

Materials

a. waterBody: Baltic; country: Sweden; maximumDepthInMeters: 0.02; verbatimLatitude: 58°46,00'N; verbatimLongitude: 17°49,52'E; year: 2011; month: 5; day: 26; habitat: Soft sediment; individualCount: 3; sex: 2 females, 1 male; catalogNumber: SMNH-177084; identifiedBy: O. Holovachov; dateIdentified: 2018

b. waterBody: Skagerrak; country: Sweden; locality: Gullmarsfjord, near Fiskebäckskil; minimumDepthInMeters: 8; maximumDepthInMeters: 15; verbatimLatitude: 58° 15,09'N; verbatimLongitude: 11°27,54'E; year: 2011; month: 8; day: 11; habitat: Muddy sand; individualCount: 1; sex: female; catalogNumber: SMNH-177085; identifiedBy: O. Holovachov; dateIdentified: 2018

c. waterBody: Baltic; country: Sweden; locality: Öregrund; minimumDepthInMeters: 38; maximumDepthInMeters: 38; verbatimLatitude: 60°24,21'N; verbatimLongitude: 18° 29,10'E; year: 2011; month: 5; day: 19; habitat: Soft mud with clay; individualCount: 2; sex: 1 female, 1 juvenile; catalogNumber: SMNH-177086; identifiedBy: O. Holovachov; dateIdentified: 2018

d. waterBody: Skagerrak; country: Sweden; locality: Bratten; minimumDepthInMeters: 45; maximumDepthInMeters: 55; verbatimLatitude: 58°17,32'N; verbatimLongitude: 11° 11,24'E; year: 2011; month: 8; day: 9; habitat: Coarse sediment with algae; individualCount: 2; sex: female; catalogNumber: SMNH-177087; identifiedBy: O. Holovachov; dateIdentified: 2018

e. waterBody: Skagerrak; country: Sweden; locality: Bratten; minimumDepthInMeters: 30; maximumDepthInMeters: 70; verbatimLatitude: 58°22,14'N; verbatimLongitude: 11° 05,00'E; year: 2011; month: 8; day: 9; habitat: Gravel, mud, algae; individualCount: 2; sex: male; catalogNumber: SMNH-177088; identifiedBy: O. Holovachov; dateIdentified: 2018

f. waterBody: Baltic; country: Sweden; maximumDepthInMeters: 0.02; verbatimLatitude: 58°46,00'N; verbatimLongitude: 17°49,52'E; year: 2011; month: 5; day: 26; habitat: Soft sediment; individualCount: 1; sex: female; catalogNumber: SMNH-177089; identifiedBy: O. Holovachov; dateIdentified: 2018

g. waterBody: Skagerrak; country: Sweden; locality: Bratten; minimumDepthInMeters: 139; maximumDepthInMeters: 153; verbatimLatitude: 58°34,19'N; verbatimLongitude: 10°38,20'E; year: 2012; month: 10; day: 12; habitat: Soft bottom; individualCount: 1;

sex: female; catalogNumber: SMNH-177090; identifiedBy: O. Holovachov; dateIdentified: 2018

h. waterBody: Skagerrak; country: Sweden; locality: Gullmarsfjord, Kristineberg-Lysekil; minimumDepthInMeters: 53; maximumDepthInMeters: 53; verbatimLatitude: 58° 15,73'N; verbatimLongitude: 11°26,10'E; year: 2014; month: 8; day: 14; habitat: Mud; individualCount: 1; sex: female; catalogNumber: SMNH-177092; identifiedBy: O. Holovachov; dateIdentified: 2018

i. waterBody: Skagerrak; country: Sweden; locality: Bratten; minimumDepthInMeters: 139; maximumDepthInMeters: 153; verbatimLatitude: 58°34,19'N; verbatimLongitude: 10°38,20'E; year: 2012; month: 10; day: 12; habitat: Soft bottom; individualCount: 1; sex: female; catalogNumber: SMNH-177098; identifiedBy: O. Holovachov; dateIdentified: 2018

j. waterBody: Skagerrak; country: Sweden; locality: Gullmarsfjord, near Fiskebäckskil; minimumDepthInMeters: 44; maximumDepthInMeters: 44; verbatimLatitude: 58° 15,63'N; verbatimLongitude: 11°27,72'E; year: 2011; month: 8; day: 11; habitat: Soft mud; individualCount: 1; sex: male; catalogNumber: SMNH-177109; identifiedBy: O. Holovachov; dateIdentified: 2018

k. waterBody: Skagerrak; country: Sweden; locality: Gullmarsfjord, near Fiskebäckskil; minimumDepthInMeters: 30; maximumDepthInMeters: 39; verbatimLatitude: 58° 15,13'N; verbatimLongitude: 11°27,31'E; year: 2010; month: 8; day: 21; habitat: Mud; individualCount: 1; sex: female; catalogNumber: SMNH-177112; identifiedBy: O. Holovachov; dateIdentified: 2018

l. waterBody: Baltic; country: Sweden; locality: Höga Kusten; minimumDepthInMeters: 86; maximumDepthInMeters: 86; verbatimLatitude: 62°49,10'N; verbatimLongitude: 18° 23,44'E; year: 2011; month: 5; day: 23; habitat: Silty mud on rather stiff clay; individualCount: 1; sex: female; catalogNumber: SMNH-177121; identifiedBy: O. Holovachov; dateIdentified: 2018

m. waterBody: Skagerrak; country: Sweden; locality: Bratten; minimumDepthInMeters: 139; maximumDepthInMeters: 153; verbatimLatitude: 58°34,19'N; verbatimLongitude: 10°38,20'E; year: 2012; month: 10; day: 12; habitat: Soft bottom; individualCount: 1; sex: female; catalogNumber: SMNH-177125; identifiedBy: O. Holovachov; dateIdentified: 2018

n. waterBody: Skagerrak; country: Sweden; locality: Gullmarsfjord, near Fiskebäckskil; minimumDepthInMeters: 30; maximumDepthInMeters: 30; verbatimLatitude: 58° 15,25'N; verbatimLongitude: 11°27,30'E; year: 2011; month: 8; day: 11; habitat: Soft mud; individualCount: 1; sex: female; catalogNumber: SMNH TYPE-9205 (same slide as *C. triclados*); identifiedBy: Oleksandr Holovachov; dateIdentified: 2018

o. waterBody: Skagerrak; country: Sweden; locality: Gullmarsfjord, near Fiskebäckskil; minimumDepthInMeters: 30; maximumDepthInMeters: 30; verbatimLatitude: 58° 15,25'N; verbatimLongitude: 11°27,30'E; year: 2011; month: 8; day: 11; habitat: Soft mud; individualCount: 1; sex: female; catalogNumber: SMNH TYPE-9207 (same slide as *C. triclados*); identifiedBy: Oleksandr Holovachov; dateIdentified: 2018

Description

Measurements. Table 1. **Adult. Figs 1, 2, 3.** Cuticle without longitudinal striation. Space between dorsal and ventral limbs of amphid not developed (Fig. 2a). Lateral alae narrow, appearing externally as two straight lines encompassing entire length of amphid. It originates at level with anterior edge of amphid, extends posteriorly as two

lines parallel and very close to ventral limb of the amphid (Fig. 2b) and ends at level of posterior fifth of tail by merging with posterior end of ventral limb of amphid (Fig. 3c, d). Secretory-excretory pore opens posterior to cardia, at level with anterior part of intestine (Fig. 2d). Tail with clavate terminal part. **Male.** Anteriormost edge of amphid positioned just posterior to oral opening. Dorsal limb of amphid extends for a short distance posteriorly, equal to 2.2–2.7 labial region diameters in length. Ventral limb of amphid extends along entire body to posterior fifth of tail. Ventral limb of amphid is 1.0–1.5 wider than dorsal limb. Spicules with rounded manubrium and subcylindrical, arcuate shaft (Fig. 3a). Gubernaculum with dorsal apophysis (Fig. 3b). Precloacal supplements/sensilla invisible in current specimens. Two pairs of ventrosublateral setae located along posterior half of tail and one pair of sublateral setae located subterminally. **Female.** Anteriormost edge of amphid positioned just posterior to oral opening. Dorsal limb of amphid extends for a short distance posteriorly, equal to 2.1–2.3 labial region diameters in length. Ventral limb of amphid extends along entire body to posterior fifth of tail. Ventral limb of amphid is 1.5 wider than dorsal limb. Vagina straight (Fig. 2e, f). One pair of ventrosublateral setae located along middle of tail and one pair of sublateral setae located subterminally.

Table 1.

Morphometrics of *Campylaimus gerlachi* Timm, 1961 and *Campylaimus minutus* Fadeeva, Mordukhovich & Zograf, 2016.

Species	***C. gerlachi***		***C. minutus***	
Number and gender	3 males	4 females	2 males	5 females
Body length	416 (373–471)	449 (343–515)	504; 382	422±80 (355–555)
Body diameter	15 (14–16)	20 (18–23)	14; 14	19±5 (12–26)
Pharyngeal region length	84 (77–91)	94 (68–110)	84; 86	85±15 (70–107)
Tail length	68 (61–75)	84 (65–98)	58; 60	59±12 (49–79)
Cloacal/anal body diameter	13 (12–13)	12 (11–12)	12; 12	12±5 (8–19)
a	28 (26–30)	22 (19–26)	35; 28	24±5 (20–32)
b	5.0 (4.8–5.2)	4.8 (4.4–5.2)	6.0; 4.4	5.2±0.5 (4.6–5.7)
c	6.1 (5.9–6.3)	5.3 (5.3–5.5)	8.7; 6.4	7.2±0.2 (7.0–7.5)
c'	5.3 (4.7–5.7)	7.3 (5.5–8.9)	4.6; 5.1	5.3±0.9 (4.1–6.0)
V	–	52 (50–53)	–	53±1 (52–54)
Labial region diameter	8	8 (8–9)	7; 6	6±1 (5–8)
Cephalic setae length	2	2 (1–2)	2; 2	1
Subdorsal setae bases from anterior end	9 (9–10)	10 (8–13)	8; 7	8±3 (6–10)
Subventral setae bases from anterior end	9 (8–10)	8	7; 7	7±2 (5–8)
Oral opening from anterior end	5 (3–6)	5 (4–6)	5; 5	4±1 (3–6)